2045

PHYTOTOXICOLOGY SOIL AND VEGETATION LEAD ASSESSMENT SURVEYS IN THE VICINITY OF HIGHWAY 401, TORONTO 1972, 1979 AND 1990

AUGUST 1992

Ontario
Environment
Environnement

2/10/92

ISBN 0-7778-0029-2

PHYTOTOXICOLOGY SOIL AND VEGETATION LEAD ASSESSMENT SURVEYS IN THE VICINITY OF HIGHWAY 401, TORONTO - 1972, 1979 AND 1990

Report prepared by:

R.N. Emerson
Phytotoxicology Section
Air Resources Branch
Ontario Ministry of the Environment

AUGUST 1992

Cette publication technique
n'est disponible qu'en anglais.

Copyright: Queen's Printer for Ontario, 1992
This publication may be reproduced for non-commercial purposes
with appropriate attribution.

PIBS 2085
Log 92-2231-016

Phytotoxicology Soil and Vegetation Lead Assessment Surveys in the Vicinity of Highway 401, Toronto - 1972, 1979 and 1990

Introduction

In 1972, the Phytotoxicology Section initiated a soil and vegetation lead study in the vicinity of Highway 401, Toronto. The study was conducted on the Hydro right-of-way, which crosses the highway, just west of Warden Avenue. The sampling program was designed to determine the degree and extent of vehicular lead emission contamination of soil and vegetation to the north and south of the highway.

The purpose of the resampling was 1) to determine if there had been a change in the lead concentration pattern over time and 2) to examine the effects of noise barriers placed along both sides of the highway in 1973. The possibility that wind eddying could concentrate lead deposits on the leeward side of the 2-3 meter-high barriers prompted the Ministry of Transportation to request the investigation in 1979.

Lead accumulation in soil is a long-term process and the detection of low annual accumulations is complicated by the inherent natural variability in the lead content of soil. In contrast, vegetation (plant foliage) provides a better indication of current emissions; however, it is subject to environmental variables such as the cleansing action of rainfall and the heterogeneity of the foliage (particularly grasses) from one site to another.

In 1979, Phytotoxicology staff (Messrs. Pearson and Emerson) searched the highway for suitable areas that would provide the necessary information. Both sides of the highway were searched to locate areas where plant foliage could be sampled on both sides of the sound barrier and at increasing distances from the pavement edge. The area also had to allow comparable sampling and be subjected to similar exhaust emissions but to have no noise barriers.

As the investigators were unsuccessful in locating such an area that was accessible, the decision was made to re-sample in 1979 the 1972 study area (west of Warden Avenue), where barriers were now present on both sides of the highway. As the sampling of this study area in 1972 was conducted prior to the placement of the noise barriers, it was felt that the data could be useful as background or reference levels with which to compare the corresponding post-barrier contamination pattern. It was acknowledged that the use of the 1972 data in this manner was subject to several uncontrolled variables that could affect the validity of any direct numerical comparisons. Some of these include frequency and amount of rainfall, prevailing winds, changes in the degree of vehicle lead emissions and changes in traffic volume. In spite of these influencing variables, it was felt that some useful information could be obtained from the re-sampling in 1979. The same sites were also sampled in 1990.

In 1979 and 1990, forage also was sampled from an area on the south side of Highway 401, just west of Bayview Avenue.

In the Warden Avenue study area, average daily traffic volumes on higway 401 have increased from 126400 in 1972, and from 190300 in 1979, to 305500 in 1990. The Ministry of Transportation found a similar trend in the Bayview study area, where the average daily traffic volumes were 151850 in 1972, 207100 in 1979 and 285500 in 1990.

Sample Collection Program

From the hydro corridor, just west of Warden Avenue, in each of the three sample years, soil and grass samples were collected at increasing distance to the north and south of the highway pavement as illustrated in Figure 5. In all years, samples were collected from the same general site areas except that in 1979 the sampling distance for three north sites (3-N, 4-N, 5-N) was slightly altered from 1972. On the north side of the highway, all sampling sites in 1979 and 1990, with one exception (Site 1-N), were located to the north of the noise barrier, which was situated approximately 15 meters north of the highway. Site 1-N was situated adjacent to the highway. All sites on the south side of the highway were situated to the south of the noise barrier, which was situated atop the highway retaining wall. At each site, in addition to collecting grass, soil was collected at two depths (0-3 cm; 3-10 cm). The samples were collected along a line parallel to the highway, using otherwise standard sampling procedures.

In the other study area (west of Bayview Avenue), grass sampling in 1979 and 1990 was performed at two sites on the south side of Highway 401. Both sites were located about 4-5 meters south of the pavement. Site 1 was situated on the protected (leeward) side of the noise barrier, while no barrier was present at Site 2, which was directly exposed to vehicle emissions (see Figure 5).

The investigations were conducted in September in both 1990 and 1979, and in July of 1972. At each site, triplicate samples of soil and of grass were collected, except in 1972 when single samples were collected.

The samples were returned to the Phytotoxicology processing laboratory. Here the samples were dried and ground and stored in glass jars. They were then submitted to the MOE Laboratory Services Branch for lead analysis.

Results and Discussion

The soil and forage results are presented in Tables 1 and 2, which also show the corresponding Upper Limit of Normal (ULN) guidelines established by the Phytotoxicology Section.

Soil Results

In the study area west of Warden Avenue, the lead concentration of surface soil (0-3 cm) at sample Site 1-N, which was closest to the north side of Highway 401, has increased dramatically with each sampling interval. In 1972, the soil lead concentration at this site was 195 ppm, which was comparable to urban soil lead levels in areas of Toronto not exposed to a major highway. In 1979, the lead concentration rose to 373 ppm. By 1990, Site 1-N had a lead concentration in the surface soil of 740 ppm, which is significantly above the urban ULN guideline of 500 ppm. In all years, there was a consistent pattern of decreasing soil lead concentration with increasing distance from Highway 401 at all five north sample sites (1-N to 5-N), as illustrated in Figure 1. The greatest concentration gradient (sharpest decline) occurred between Sites 1-N and 2-N, or within 15 meters of the highway, where the soil lead level fell from over 700 ppm adjacent to the road to about 100 ppm at 15 meters. From this point, the concentration gradient was considerably less steep, declining from about 100 ppm to about 30 ppm at 160 meters. This pattern was very similar for the deeper soil samples (3-10 cm) from the north of the highway. At Site 1-N (next to Hwy. 401), the lead concentration in the deeper soil (3-10 cm) rose dramatically between 1979 (67 ppm) and 1990 (700 ppm), with the concentration of 700 ppm in 1990 being above the 500 ppm ULN. This was the only north site where a dramatic increase in lead concentrations in the deeper soil occurred between 1972 and 1990.

To the south of Highway 401, the pattern of soil lead concentration in relation to distance from the highway was very similar for the six south sample sites (1-S to 6-S); i.e., rapidly decreasing concentrations with increasing distance from the 401, and higher concentrations in the surface soil samples (0-3 cm) compared with the deeper samples (3-10 cm). There was, however, one exception. At Site 1-S, the surface soil lead concentration decreased from over 700 ppm in 1979 to about 200 ppm in 1990. This site was situated in a depressed area (beside drainage ports in retaining wall) where the drainage pattern has resulted in soil deposition over the years. This soil buildup is suspected to have contributed to the dilution of lead concentrations in the surface soil (0-3 cm) in this area between 1979 and 1990. The barrier may also have partly contributed to the decrease, as it likely retains the highway emissions and dust. In contrast, lead concentrations in the deeper soil (3-10 cm) at Site 1-S, during the same interval (1979-1990), rose marginally to over 500 ppm in 1990 (577 ppm). At all south sample sites, lead concentrations have increased in the deeper soil with each sampling interval, an indication that lead has leached from the surface soil into the deeper soil. Figure 2 shows that the lead concentration of the deeper soil at all sites on the north side of the highway also has increased since 1972. However, some of the increase could be associated with sampling and/or inherent variability of lead in soil. Regardless, all south and north sites in 1990, with exception of the two sites beside the highway (1-S and 1-N), had a lead concentration in the deeper soil (3-10 cm) that was very low compared to the 500 ppm ULN.

Forage Results

In the study area west of Warden Avenue, each year, the highest lead concentrations in forage also were detected at Sites 1-N and 1-S, adjacent to the highway. Similar to the soil data, lead concentrations in forage decreased with increasing distance from the road in all three sample years, including 1972, when no barriers were present (see Figure 3, which excludes the anomolous 15 ppm result at Site 2-S in 1972). As a decreasing pattern with distance from the highway would be expected regardless of the presence or absence of the barriers, it is difficult to ascertain the degree of leeward deposition which may be directly associated with wind eddying created by the 2-3 meter tall barriers. However, as the 1979 and 1990 (post-barrier) forage results for both sides of the highway revealed only a slight concentration gradient through to 30-40 meters of the highway on the leeward side of the barriers, lead accumulation associated with wind eddying would appear not to be very significant. The north barrier was situated about 15 meters north of the highway, while the south barrier was situated immediately adjacent to the traffic lanes. These solid barriers are likely having the opposite effect, by confining the lead emissions and dust to the highway corridor. Vegetation and soil beyond the barriers are being afforded some protection.

In the study area west of Bayview Avenue, the grass collected at Site 1 behind the barrier had a lower lead concentration than Site 2 where there was no barrier, an indication that the barrier is providing some protection (see Figure 4). These results further suggest that possible wind eddying created by the 2-3 meter-high barriers is not contributing to any significant lead accumulation on the leeward side of the barriers (see Table 2 below).

Table 2:
Lead Concentrations in Grass West of Bayview Ave., Toronto - 1979 and 1990

Sample Location (Figure 5)	Lead Concentration (ppm, dry wt.) 1979	1990
Site 1 (S of barrier)	13	2
Site 2 (no barrier)	33	7

Result underlined exceeds 20 ppm rural ULN.
Urban ULN not established

In both survey areas, lead concentrations in forage have decreased dramatically since 1979, as shown on Figures 3 and 4. In 1979 and 1972, grass lead concentrations of about 50 ppm were found at the most contaminated sites and several sites exceeded the 20 ppm rural ULN (there is currently no urban grass ULN). By 1990, forage lead concentrations at the most contaminated sites had dropped to 5-7 ppm, which is well below the ULN. As annual average daily traffic volumes on Highway 401 have increased dramatically over the study period (1972-1990), the reduction in lead levels in vegetation has likely resulted from the reduced use of leaded gasoline in recent years.

Summary

In summary, the soil results for the three sample years (1972, 1979 and 1990) revealed the most dramatic increase in soil lead concentrations at Site 1-N, adjacent to the north side of the highway. At this site, in 1990, the lead content of both the surface soil (740 ppm) and the deeper soil (700 ppm) was greater than the 500 ppm ULN. Lead concentrations at Site 1-S (behind barrier on south side of highway) were reduced significantly in the surface soil in 1990 (200 ppm) from 1979 (767 ppm) and were increased slightly in the deeper soil in 1990 (577 ppm). This pattern was suspected to be largely related to the drainage pattern and buildup of soil in this area. At sample sites beyond 3 meters of the pavement, lead concentrations at both soil depths decreased with increasing distance both to the north and to the south of the highway and were well below the ULN guideline. Lead concentrations in the surface soil generally were higher than in the deeper soil and the soil results suggested that there has been some leaching of lead from the surface soil into the lower soil.

The forage results revealed a similar concentration gradient with increasing distance from the highway and suggested that the noise barriers are providing some protection from lead emissions, as opposed to contributing to concentrated levels on the leeward side. In both study areas, lead concentrations in forage were markedly reduced in 1990 compared to 1979 and 1972. This reduction is suspected to be largely associated with the reduced use of leaded gasoline in recent years.

In conclusion, based on the limited data obtained for the three sampling dates between 1972 and 1990, the noise barriers appear to be confining vehicle emissions to the highway corridor. The forage data suggest that ambient lead levels have declined. However, the soil data suggest that soil lead concentrations along the highway corridors within the noise barriers may not yet have peaked.

Table 1: Lead Concentrations in Soil and Grass in the Vicinity of Highway 401, Toronto - 1972, 1979 and 1990

Site No.	Distance from Hwy.*	Average** Lead Concentration (ppm, dry wt.)								
		Soil (0-3cm)			Soil (3-10cm)			Grass		
		1972	1979	1990	1972	1979	1990	1972	1979	1990
North of Highway 401										
5-N	160 m N	40	41	31	28	26	24	6	12	1
4-N	40 m N	55	73	61	30	35	51	11	21	1
3-N	25 m N	75	85	80	35	49	62	18	26	1
2-N	15 m N	88	100	107	40	60	84	20	33	2
1-N	3 m N	195	373	740	83	67	700	56	48	5
South of Highway 401										
1-S	0.3 m S	NS	767	200	NS	467	577	NS	34	5
2-S	4 m S	300	263	220	88	118	160	15	33	2
3-S	7 m S	183	182	173	65	67	137	53	31	2
4-S	15 m S	100	133	123	43	72	96	37	30	1
5-S	30 m S	88	89	90	33	51	69	27	29	2
6-S	150 m S	73	58	50	30	31	37	9	14	1
ULN Guideline		500						20		

* Distance values in 1972 were slightly different for Sites 3-N (30 m), 4-N (60 m), and 5-N (150 m)

** Average of triplicate sample replicates except in 1972. In 1972, a single sample per site was collected. The collections dates were July 27, 1972; September 19, 1979; September 20, 1990

ULN - Phytotoxicology Section Upper Limit of Normal guidelines for urban soil (0-5 cm) and rural grass, see Appendix

NS - Not sampled in 1972

Note: Values underlined exceed ULN

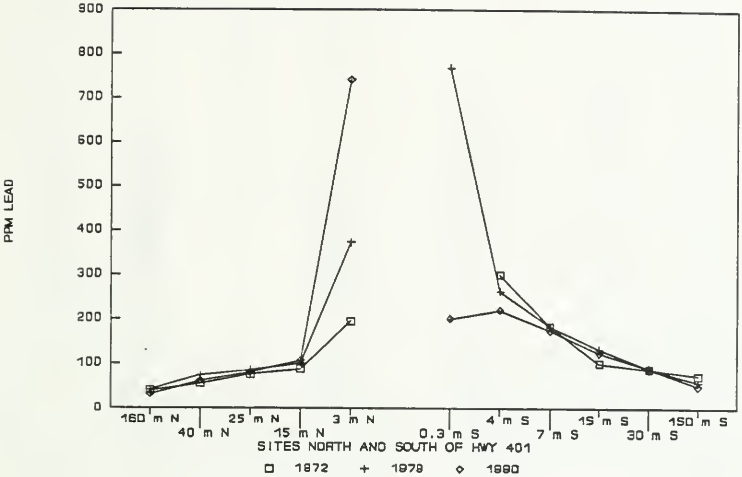


Figure 1: Lead Concentration in Surface Soil (0-3 cm) North and South of Highway 401, 1972-1990

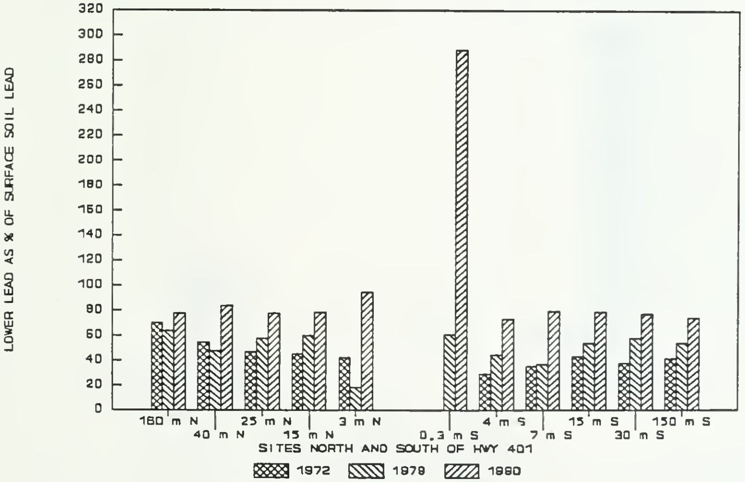


Figure 2: Lead Concentration in Sub-Surface Soil (3-10 cm) as Percent of Surface Soil (0-3 cm) at Sites North and South of Highway 401, 1972-1990

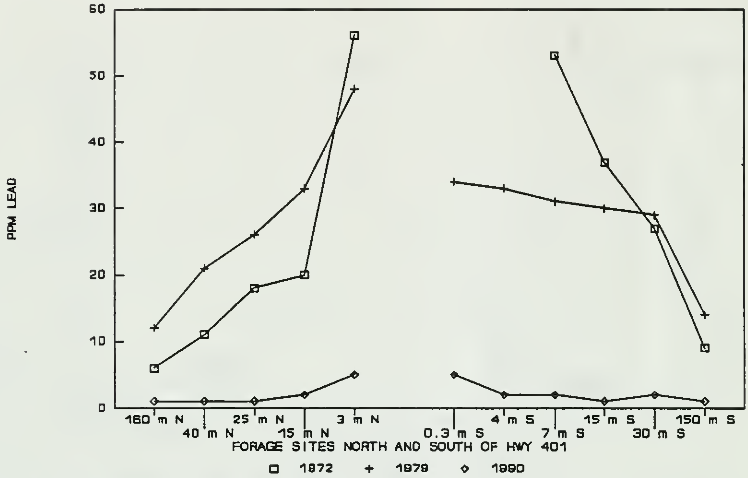


Figure 3: Lead Concentration in Grass Samples Collected North and South of Highway 401, 1972-1990

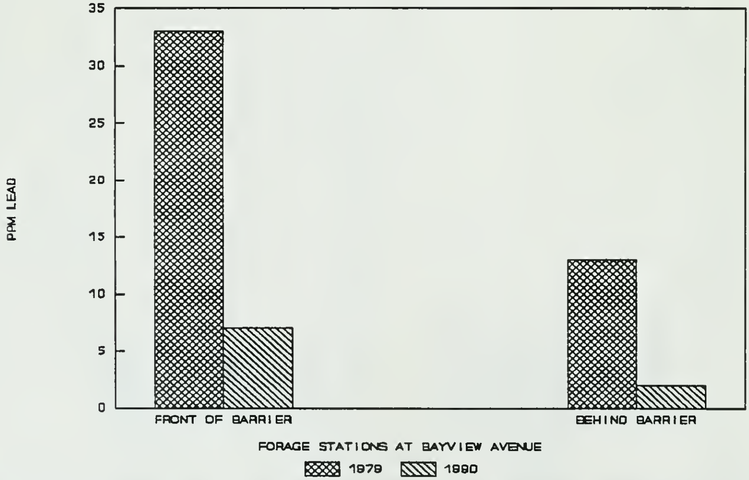
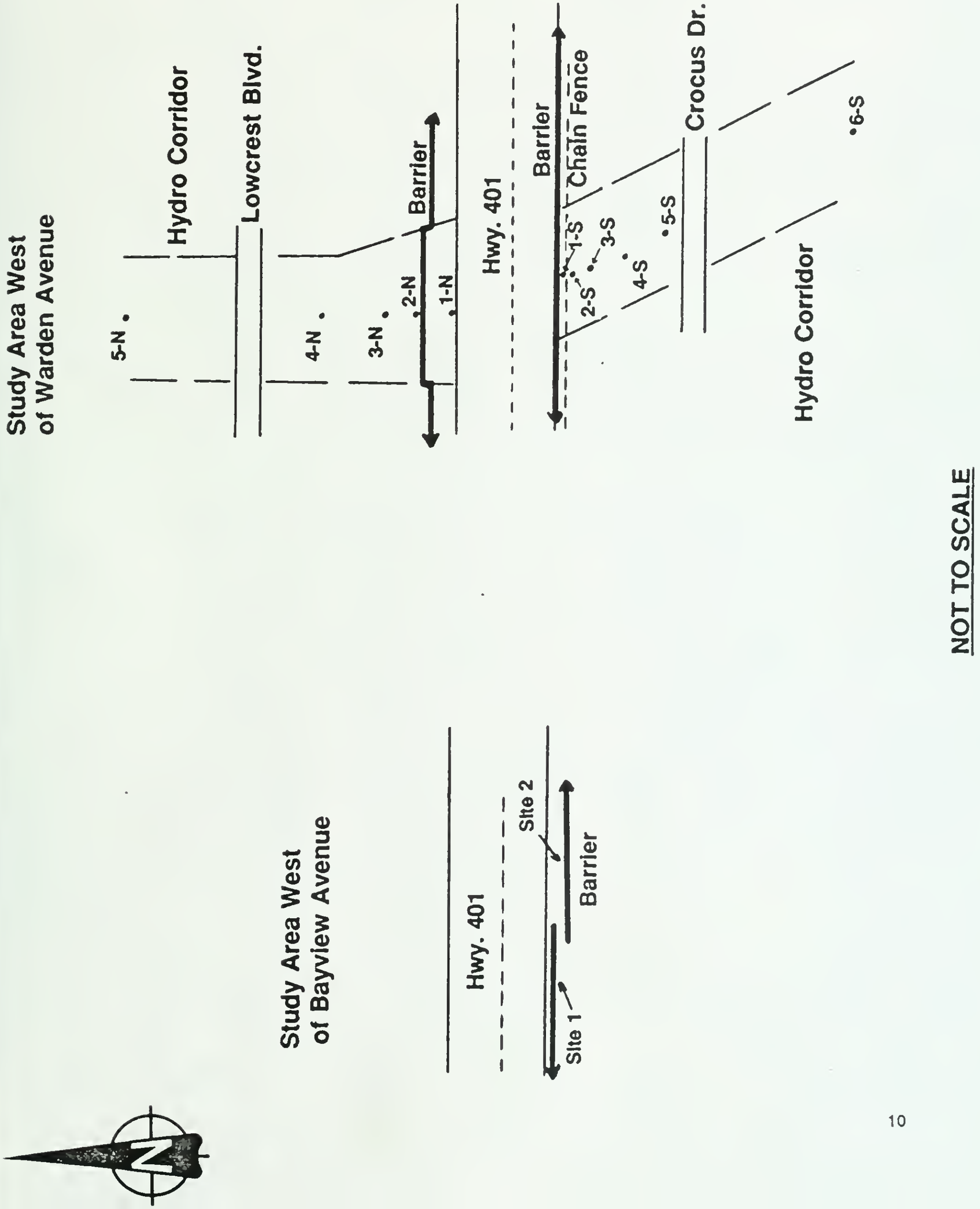


Figure 4: Effect of Noise Barriers on Lead Concentrations in Grass Samples Collected in the Vicinity of Bayview Avenue, 1979 and 1990

Figure 5: Sampling Locations/Sites in the Vicinity of Highway 401, Toronto - 1972, 1979 and 1990



Appendix

Derivation and Significance of the MOE Phytotoxicology "Upper Limits of Normal" Contaminant Guidelines.

The MOE Upper Limits of Normal (ULN) contaminant guidelines represent the expected maximum concentration in surface soil, foliage (trees and shrubs), grass, moss bags, and snow from areas in Ontario not exposed to the influence of a point source of pollution. Urban ULN guidelines are based on samples collected from developed urban centres, whereas rural ULN guidelines were developed from non-urbanized areas. Samples were collected by Phytotoxicology staff using standard sampling procedures (ref: Ontario Ministry of the Environment 1983, *Phytotoxicology Field Investigation Manual*). Chemical analyses were conducted by the MOE Laboratory Services Branch.

The ULN is the arithmetic mean, plus three standard deviations of the mean, of the suitable background data. This represents 99% of the sample population. This means that for every 100 samples which have not been exposed to a point source of pollution, 99 will fall within the ULN.

The ULNs do not represent maximum desirable or allowable limits. Rather, they are an indication that concentrations that exceed the ULN may be the result of contamination from a pollution source. Concentrations that exceed the ULNs are not necessarily toxic to plants, animals, or people. Concentrations that are below the ULNs are not known to be toxic.

ULNs are not available for all elements. This is because some elements have a very large range in the natural environment and the ULN, calculated as the mean plus three standard deviations, would be unrealistically high. Also, for some elements, insufficient background data is available to confidently calculate ULNs. The MOE Phytotoxicology ULNs are constantly being reviewed as the background environmental data base is expanded. This will result in more ULNs being established and may amend existing ULNs.